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Modelling in A.L.W.T. the Dynamic Characteristics of the Wind in Mixed Climates

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Summary

The climate behaviour suffers important changes as result of the impact with a rapid extension of the anthropic space. The abrupt modification of season temperature and severe wind storms are put in evidence now all over the world.

Simulation of the dynamic effects of wind action upon the built environment in laboratory is a process of scaling at reduced dimensions of a complex combination of factors insuring similarity between the natural phenomenon and the one artificially reproduced.

Usually, the design wind dynamic action on structures is identified with the so-called extra-tropical depressions, specific for middle global latitudes; the atmosphere is considered neutrally stratified, the vertical profile is in equilibrium with the terrain roughness in A.B.L. The simulations of wind speeds and pressures in the boundary layer of the air moving at the surface of the earth are based on vertical profile of the mean speeds, turbulence intensity, spectral power and histograms of the recorded values. The analysis of data is based on the model of the wind speed in A.B.L. fairly considered as a random, stationary, Gaussian process.

Lately, the observations put in evidence the fact that it is the strong winds associated with thunder storms along with the so called gust fronts that affect the built environment and that they are not stationary and Gaussian processes. The paper presents the analysis of series of measured speeds in the wind tunnel SECO 2 at different time intervals, different sampling rates in different types of boundary layers, analyzing the possibility of reproducing some of the characteristics of the wind speed in a non-neutrally stratified boundary layer.

KEYWORDS: wind tunnel simulations, wind profile in A.B.L., statistic distributions of wind speed

1. INTRODUCTION

It is rational to think that, by improving the quality of the research background, the results of laboratory studies will increase in precision; this would further result in the coherence of the theoretical concepts. Almost all the studies developed by scale modelling of different structures in atmospheric boundary layer wind tunnels are based on the theories developed in the years of 1960 on the character of the dynamic action of the wind in the proximity of the ground surface. The formulation introduced by Davenport [1] on the design wind velocity acting on structures uses a time interval of averaging between 10 minutes and 1 hour, based on the representation of van der Hoven spectrum which points out the spectral gap separating the macro- and micro-meteorological peaks; the process is approached on statistical bases as a random, stationary, Gaussian process and the atmosphere is considered neutrally stratified, the velocity vertical profile being in equilibrium with the terrain roughness. Consequently, the intensity of the design wind velocity is established in a probabilistic framework, by safely assuming for the mean wind velocity a suitable return period. This whole theory is valid for the usually atmospheric conditions identified with extra-tropical depressions typical of temperate countries at mid-latitudes.

The development of modern infrastructure of our society faces unpredicted confrontations with natural violent manifestations and the engineers' awareness is increasing on the fact that thunderstorms and strong winds must play a key role on wind actions and effects on structures [2], because their extreme effects might not be estimated correctly in the first place.

It seems that a more accurate definition is necessary, based on long and short time periods of observation of the interaction between the wind in the atmospheric boundary layer and the structures placed on the ground. Indeed, which is called now as "mixed climate" refers to "a climatology in which wind phenomena of different nature coexist" [3].

The most aggressive frequent manifestations, thunderstorms, are phenomena of convective nature and by the rapid air downburst directed to the ground level, radial outflows of air are directed all around and generating burst of different size, macro and micro. It is obvious and already stated in published research papers that these events are characterized by a random process of velocity which is non-stationary and non-Gaussian; in particular, the vertical profile of the velocity is nearly independent of the terrain roughness and has a typical nose shape fully different from the shape that characterizes extra-tropical depressions. It is now widely recognized that wind phenomena with a return period greater than 10–20 years are often associated with thunderstorms.

Recent studies show in addition to extra-tropical depressions and thunderstorms, another wind phenomena of intermediate properties, also called "gust fronts" [4],

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[5], for which the wind velocity tends to be stationary but not Gaussian. For this kind of manifestations of wind action, the mean velocity is rather limited but turbulence is very high and causes peaks of relevant intensity, the velocity records showing high atmospheric instability.

The basic study of wind velocity and the structural response in these combined situations is dependent on the huge amount of data available up to now, obtained from atmospheric neutral stable phenomena with regard to extra-tropical depressions and disregards by quasi total lack of information the later observed phenomena, associated with the instable atmospheric conditions.

If the studies in boundary layer wind tunnels regarding wind effects on structures will admit the mixed climate existence, then appropriate simulations should be taken into account. Knowledge on this respect must have in view the characteristics of the wind action in instable atmosphere along with all the implications included. The basic studied feature of the wind velocity random process would in this case be the possibility of associating it with the statistic attributes.

UPDATES IN WIND SPEED MEASUREMENTS

2.1 Wind velocity measurements at site

The raw data regarding wind speed and directions of action are obtained through standard methods. Anemometers placed in open fields, quite frequently in the proximity of airports are able to gather wind velocity values averaged from seconds to 1 hour simultaneously with the direction of action at 10 meters high above the ground. The recorded raw data are further transmitted and afterwards transformed into more datasets associated with different wind phenomena.

The wind velocity characteristics measured at site are:

- the fundamental reference speed, which is a mean value obtained by averaging over 10 minutes period the values obtained from the anemometer, without considering the direction of action and the season and determined at 10 meters above the ground level on a standard terrain of II category of roughness, [6] and [7] ;
- correction factors because of the variation of the wind intensity with the direction and also with the season;
- the correction factor that takes into account the annual probability of exceeding the mean speed obtained from averaging the measured data over 10 minutes, determined with [7]:

$$c_{prob} = \left(\frac{1 - 0.2 \cdot \ln(-\ln(1-p))}{1 - 0.2 \cdot \ln(-\ln(0.98))} \right)^{0.5} \quad (1)$$

All the data concerning the reference values of the wind speed and pressure for different particular sites are presented in Eurocode and in the annex to Eurocode referring to national specific values. And although these data contain sets of maxima values during 10 minutes records, daily, annual or even the absolute maximum from the period of observation (in Romania being between 20 to 50 years), they do not include information concerning the synoptic nature of the event that covers the period when these values are determined [7].

The modern trend of analysis of the wind maxima manifestations based on observations gathered at meteorological stations, discards the events into three families of properties, all being specific for the random processes, likewise:

- - events characterized by stationary and Gaussian nature for which the common features are the relative large values of the mean speed and small values of gust factors; they are extra-tropical depressions, related to neutral atmospheric conditions (no significant transitions occur inside the boundary layer);
- - non-stationary and non-Gaussian events, like the typical thunderstorms or strong winds for which the mean speed values are small but the peak values of the velocities and the gust factors are large;
- - events situated between these two mentioned above, called gust fronts accompanying the unstable atmospheric conditions; they are stationary but non Gaussian.

The definition of a stationary event refers to time periods from 10 minutes to 1 hour. The normal or Gaussian distribution of the wind speed data is adopted in connection with other processes that define the random nature of climate actions in particular and in general within the study of the safety design of structures based on the semi-probabilistic model.

It must however be mentioned here that while the data recorded by the anemometers could be analysed with the help of the Gaussian distribution, the reference or characteristic values of the wind speed provided by the codes for practice for the structural design are given in terms of maxima values, that may not be described by a Gaussian distribution, but typically by a Gumbel distribution.

The internal structure of the random process of wind speeds at site is usually studied starting with the histogram of the wind speed measures, compared with the ideal Gaussian density matching the mean wind speed and the standard deviation. As already mentioned above, it then is important to adjust the data obtained via at site measurements which are represented by the maxima values and analyzed by Gumbel maxima functions of distributions.

The analysis of similar recordings at site data, like the prodigious work of Solari and al. [2] are facing similar situations and they are not clearly statistically defined.

New methods of analysis are elaborated based on Cook's observations on storms, [8] trying to isolate the heterogeneous events from statistical monotonic data; it resulted into series of observations of wind speeds that exceed particular values of speed (threshold speeds) over specific subsequent time periods, for ex. 10 hours. This period marks an increase or a drop down of wind speed values and two sequential drop-down periods mark clearly a period during which a windstorm occurs, for example the threshold speed values that mark a lull are chosen as to take into account almost 100 storms per year; further analysis of the consequences are not developed yet.

The specific case of at site measurements on which we rely here is a set of raw data obtained from the National Meteorology Agency (A.N.M.H.) and concerns 10 years period of observation, from 1997 to 2006 in a standard II category of terrain, the airport of Iasi.

There are two types of data: averaged values from 10 minutes velocities recorded daily every 6 hours and peak velocities (the maximum successively recorded on 3 seconds intervals, a final maximum for a 10 minutes interval being chosen). Part of these data were already processed during a research program [9] and some of the results published [10], but further analyses must be developed regarding aspects related to the subject discussed here.

Table 1. Distribution and classification of maximum speed values over the period of observation

Year	Mean speed V_m	STD,σ	Maximum value, V_{max}	Minimum value, V_{min}	Gust factor, G= V_{max}/V_m	Skew	Kurtosis
1997	15.8333	4.03801	24	10	1.515789	1.177681	1.103828
1998	13.8333	1.90758	18	12	1.301205	0.853621	-0.01385
1999	15.3333	2.21108	20	12	1.304348	0.787296	-0.05455
2000	13	1.73205	18	12	1.384615	2.211083	5.323457
2001	13.4793	2.88942	24	10	1.780502	1.389032	1.991126
2002	13.3065	2.97817	25	10	1.878771	1.269169	1.925171
2003	13.3885	2.63360	22	10	1.643202	1.090796	1.930703
2004	13.1377	2.73249	22	10	1.674572	1.032397	0.617493
2005	12.9593	3.14008	24	0	1.851944	0.599442	3.183838
2006	12.7863	3.00129	28	6	2.189850	1.214529	4.229297

Some important knowledge must be mentioned:

- the Romanian code recommendations NP-082-2004 previous to the release of Eurocode 1, EN 1991-1-4/2004 gives the statistical description of the wind speeds based on 27 successive years of observations in terms of 1 minute wind speed, 1 absolute maximum value/year, the mean of yearly maxima values and the skew coefficient of the Gumbel distribution; also, the

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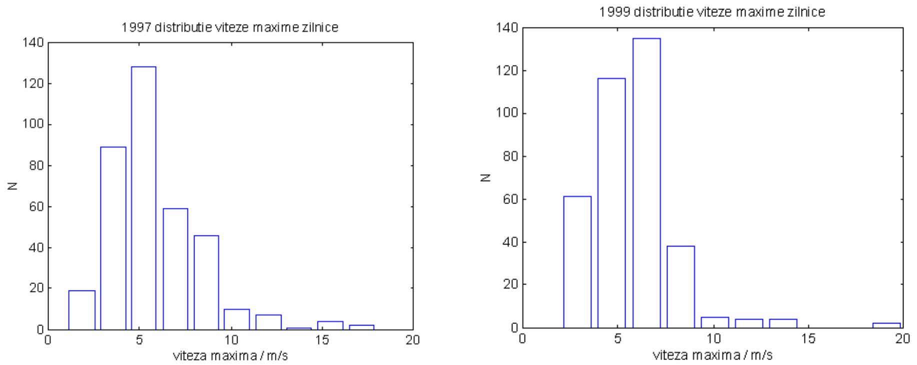
characteristic value (probability of not being exceeded of 0.98) for a standard return period, T = 50 years;

- the correlation of the skew and kurtosis coefficients of the yearly maxima on the Romanian territory corresponds to a period of time of 20….50 years.

The analysis of the distributions of yearly wind maxima speeds along the period of observation provided the values for the statistic indicators (Table 1):

The graphical representation of the distributions of measured data per year confirmed the Gumbel shape for maxima type of distribution (Figure 1 a, b):



a b

Fig 1. Distributions of daily maxima speeds at site (Iasi) per year of observation:
a- 1997; b- 1999

The distributions of mean speeds are presented in Table 2.

Table 2 Statistical data of the standard mean speed data measured at natural scale (Iasi airport) on 10 minutes period of averaging

Year	Mean speed V_m	STD,σ	Maximum value, V_{max}	Minimum value, V_{min}	Gust factor, $G= V_{max/} V_m$	Skew	Kurtosis
1997	3.0	1.8912	11.5	0.0	3.833	1.2670	2.3521
1998	2.8	1.7256	12.0	0.0	4.285	1.2149	2.5898
1999	2.7	1.6757	12.3	0.3	4.555	1.3939	3.5870
2000	3.0	1.6488	13.5	0.3	4.5	1.3780	4.1562
2001	2.9	1.2708	10.0	0.8	3.448	1.5205	4.0408
2002	2.8	1.2716	9.5	0.3	3.393	1.7498	5.1074
2003	2.9	1.2060	9.0	0.5	3.103	0.9302	1.4403
2004	2.8	1.3250	9.5	0.3	3.393	1.4729	3.1467
2005	2.7	1.2782	8.0	0.5	2.963	1.2322	1.6540
2006	2.6	1.1855	7.5	0.3	2.884	1.0477	1.4864

A graphical representation of the processed data brings to light some peculiar distributions that may be considered as anomalies, like the mean speeds presented below; being random values, we may admit that there are always possibilities of not obtaining the expected distribution, usually due to the lack of sufficient number

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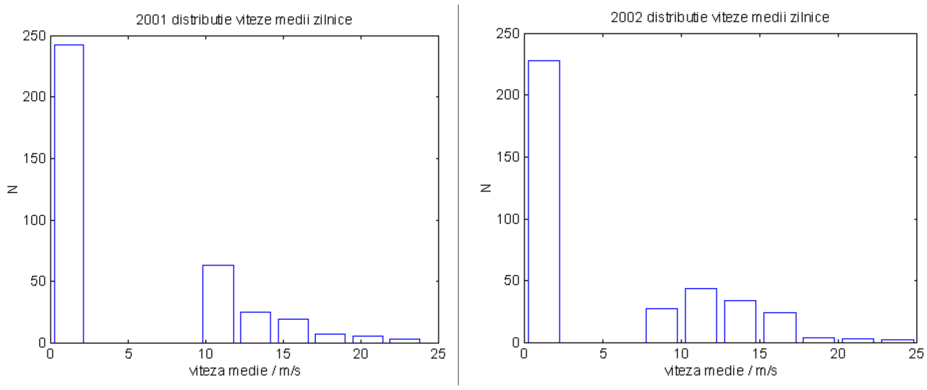
of data. But similar results of the analysis developed in the succeeding year might motivate a second thought (Figure 2 a, b); inside the observation period the successive periods of lulls are separated by a storm and the whole interval becomes non stochastic and non-stationary.

The conclusion is that these data do not correspond to the same conditions from atmospheric or synoptic point of view; more clearly, they do not characterize a neutral stable atmospheric event.



a b

Fig. 2. Distribution of the mean speed data per year: a- year 2001; b-year 2002

2.2. Wind velocity components

Wind manifestation in neutral stable atmosphere is described by the in-wind dynamic velocity *u* of the turbulent flow at a certain height; it is expressed by a relationship between the time varying mean velocity, $\bar{v}(t)$ and the fluctuating component of $v, \tilde{v}(t)$ respectively:

$$v(t) = \bar{v}(t) + v'(t) \tag{2}$$

Although a random process, the fluctuating velocity has a quasi-deterministic nature being driven by the mean value at large scale; the quantity linked to the atmospheric turbulence, is a small scale random function:

$$v(t) = \bar{v}(t)\left[1 + I_V(t) \cdot \tilde{u}(t)\right] \tag{3}$$

where I_v is referred to as the time-varying turbulence intensity:

$$I_v(t) = \frac{\sigma_v(t)}{\bar{v}(t)} \tag{4}$$

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The basis of the analysis of wind speeds in the three different kinds of manifestations relies on this decomposition because:

- in the case of neutral stable flow the mean wind velocity, the standard deviation and the turbulence intensity I_v are referred to a time interval T = 10 minutes and, on such interval, they are constant quantities and the reduced fluctuating wind velocity is a random stationary Gaussian process;
- however, in the case of thunderstorms, the mean value averaged over a 10 minutes interval is not representative.

In the modern literature scientists operate with time varying mean velocity values and moving average period T [11], for ex. 20 seconds between two extreme situations; if too large, it may be influenced by the general trend of the mean value, if too small the mean part of the velocity is contaminated by the turbulence fluctuations at small scale.

- in the case of gust fronts the mean velocity, standard deviation and turbulence intensity extracted from 10 minutes averaging interval are also constant but due to the imbalanced wind flow momentum.

Differently from extra-tropical depressions and also from thunderstorms, however, the reduced fluctuating wind velocity is a random stationary but non-Gaussian process.

3. STUDIES IN ATMOSPHERIC LAYER WIND TUNNEL AND RESULTS

3.1 Simulation of wind velocities in wind tunnel

The simulations of wind flow in atmospheric boundary layer at reduced scale are always a difficult task and it seems that they raise endless subjects of study. In reverse, there are several advantages in modelling at small scale and between them one of the most relevant is that we may fully control the characteristics of the flow inside the tunnel.

The events that reproduce the wind action at small scale in tunnel are theoretically based on the status of relative equilibrium of the dynamic pressure inside, defining the neutral stable atmosphere; in the neutral stable atmosphere a quasi-stationary flow is characterized by quasi deterministic values of the mean speed and of the turbulence intensity. Still, even for a specific constant roughness, constant values of the wind velocity are not expected, the process remaining random.

The most important aspect in modelling is perhaps the sampling rate since the scale depends on the relationship between the in space geometry and the time:

$$L_M = V_M \cdot T_M = \frac{L_P}{s} = \frac{V_P \cdot T_P}{s} \quad (5)$$

where $L_{M(P)}$, $V_{M(P)}$, $T_{M(P)}$ and s are the relevant geometric dimension, the speed and the time of the model and of the prototype and s is the scale ratio. While the geometry and the speed limits depend on the possibilities of the tunnel, the time may be adjusted as to fit the scale.

As both geometric dimensions (length scale) and the period of time associated with an event are reduced to fit the model scale (for ex. from 1/50 to more than 1/400) then adjusting to this scale means to increase the frequency of data acquisition.

Based on the assumptions previously stated regarding the Gaussian distribution of the stationary wind velocity, there are conversion relationships of speeds for different averaging time intervals [7]:

$$1.05 \cdot V_{ref}^{1h} = V_{ref}^{10\min} = 0.84 \cdot V_{ref}^{1\min} = 0.67 \cdot V_{ref}^{3\sec} \quad (6)$$

As stated before, data acquisition in the wind tunnel laboratory is mandatory and depends on the characteristics of the equipment which converts the speed or pressure signal into analogue data. The analogue data are transformed into digital data, these processes being electric signals.

The frequency of data acquisition in the laboratory corresponds to the possibilities of measuring electrical signals and high frequencies are the most usual. A consequence of the sensitivity of the measuring equipment to higher frequencies consists in reducing the time of acquisition, which is consistent with the principles of scale modelling; indeed, the time of observation is contracted in the wind tunnel in comparison with the periods of observation at natural scales, in order to fit the scale criteria. Another consequence is that, in reducing the time of acquisition in the tunnel, we practically induce the probability of producing sequential events which will not replicate themselves integrally, reflecting the character of random process although characterized by expected ("deterministic") values of mean velocity and gust values, the result of the expected turbulence and roughness length, respectively.

Still, experiments in wind tunnel rely on expected values of wind speed and pressures; they are the keystone of a reliable wind action reproduced at scale and consequently, should satisfy all the criteria imposed by both theoretical (scientific) concepts and practical experience.

The experience in these directions shows that although higher frequencies of acquisition are necessary, longer periods of acquisition are nevertheless desirable because they offer more realistic values of the statistic descriptors.

In the context of extending the knowledge for modelling different modes of manifestation of the wind action in wind tunnel, the time of acquisition and the

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frequency of sampling have their key role to play. Modelling the wind speed at small scale is mandatory and the calibration of the measured data is based on the reference values of full scale speed and pressure; the standard reference is to fit the scaled speed to the mean wind speed at 10 m above the ground level on a II category of roughness terrain.

According to the method adopted by Solari on data obtained from the anemometers [2], a prior splitting the samples in time intervals scaled to 10 minutes in nature followed by the statistical processing these data on these successive intervals is a possibility to put in evidence the parts of the event which are stationary and the non-stationary part as well. Although the phenomena that determines the manifestations of storms or of gust fronts are mainly of convective nature and air convection is difficult to be modelled in wind tunnel, their effects observed at natural scale may be artificially reproduced in wind tunnel in the conditions of similar model of wind action random manifestations.

3.2 Experiment and Results

The study presented herein is developed in the boundary layer wind tunnel SECO 2 belonging to the Laboratory of Building Aerodynamics of the Faculty of Civil Engineering and Building Services. It refers to the simulation of the wind flow over a terrain with moderate roughness, corresponding to a mean speed profile with the power law exponent α = 0.28 (see Figure 4) and the acquisition of sets of along wind speeds with the specific equipment.

Fig. 3 View inside the BLWT: a) system for generating the turbulence of the flow over an II category of terrain; b) equipment for acquisition of wind velocity

The characteristics of the wind flow in the simulated boundary layer are presented in the figure above, being in concordance with the reference natural conditions, exponent of the mean wind speed profile and the turbulence intensity.

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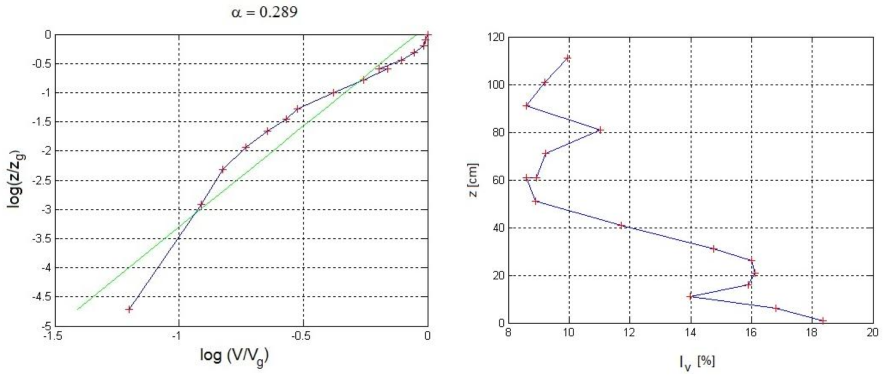
The acquisition of the wind speed is run at the reference height in laboratory for a time period of 2 minutes with a sampling rate of 1/sec, depending on the performance of the equipment, but also because we had in view the statistic distribution, not necessary the maxima values of the velocity. Data were processed over the total period of time, respectively over sequential 10 sec. time intervals. The 10 seconds extension of the periods was decided with respect to a 1/200…1/300 reduced scale of the time, corresponding to the hourly mean speed but also by knowing that the 10 minutes reference period at full scale would correspond to a period of 1…2 sec, reducing the number of sampled velocities to no more than 1 or two samples.



(a) (b)

Fig. 4 Characteristics of the simulated wind profile in wind tunnel: a) in-wind mean speed profile (exponential law); b) in wind turbulence intensity, I_v

At this point it has to be mentioned that for a representative model of the peak values recorded in nature at intervals of 10 minutes or less, the frequencies of data acquisition must be much higher than 1 Hz.

The results of the statistic processing of the data are presented in Figure 5; the first two records are the random values of the velocity v{t} during 120 seconds at heights that correspond to the full scale reference height (10 m) for the reduced scales of modelling common to the wind tunnel SECO 2 (1/200…1/400).

The records in Fig. 6 are obtained after processing the velocities measured closely to the top part of the tunnel; the turbulence of the flow in that part is under 10%, the flow becoming close to laminar, in concordance with the models of turbulence in boundary layer wind tunnels.

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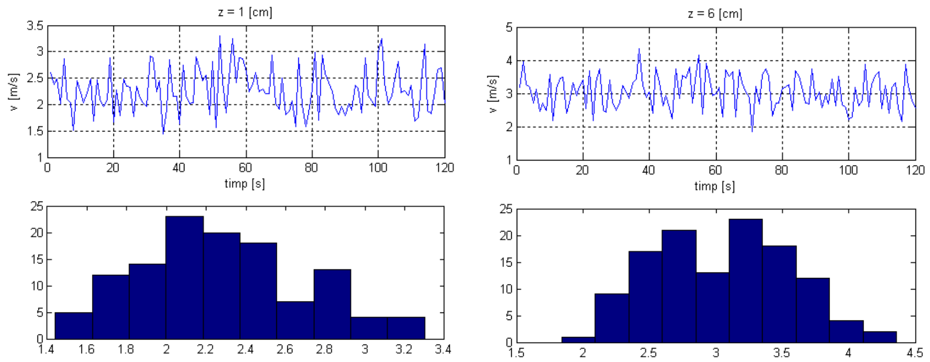
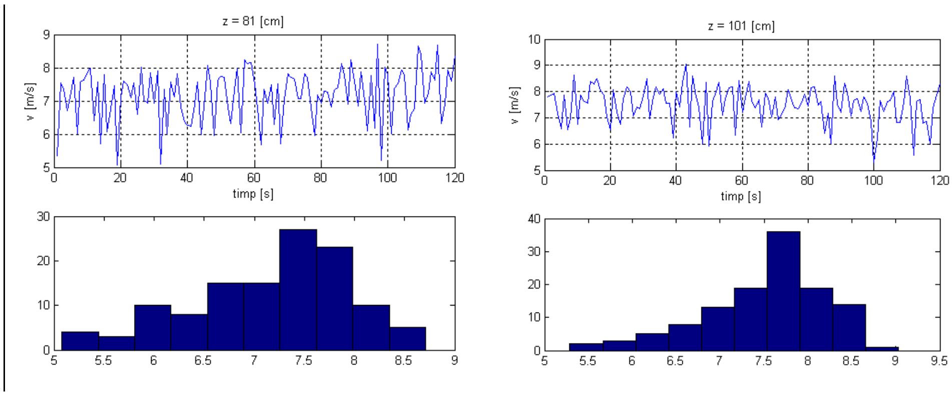


a b

Fig. 5. Recorded values of the velocity in the wind tunnel and the statistic distributions: a) - at 1 cm height; b) - at 6 cm height

A synthetic analysis of the statistical processing of the velocities measured in laboratory was developed. It was meant to put in evidence the statistic descriptors: mean values, standard deviation, ratio of maxima related to mean values (gust factors), skew and kurtosis.



a b

Fig. 6 Recorded values of the velocity in the top part of the wind tunnel and the statistic distributions: a) - at 70% of the total height of the tunnel; b) - at 85% of the total height

For a comparison between the standard velocities measured at full scale and the velocities measured in wind tunnel, the values obtained at a reference height (at 10 above the ground in nature) are presented in Table 3 below.

Table 3 Analysis of speeds measured at reference heights in nature (10 m) at time intervals corresponding to 1 hour (about 10 sec in laboratory)

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	1cm	6cm	1cm	6cm	1cm	6cm	1cm	6cm	1cm	h=6cm
1	2.40	3.40	3.15	4.42	1.3086	1.2984	0.7946	1.0209	-0.0084	1.7747
2	2.51	3.45	3.1	4.44	1.2335	1.2843	0.0734	0.7684	-0.2338	0.3655
3	2.41	2.86	3.1	3.36	1.2841	1.1715	0.6370	0.2247	-0.4754	-1.1955
4	2.41	3.09	3.15	4.38	1.3070	1.4174	0.6500	1.2859	0.40294	0.8822
5	2.66	3.07	3.1	3.73	1.1627	1.2165	-0.7597	0.0766	-0.1078	-0.8996
6	2.21	3.16	2.66	4.29	1.2014	1.3558	-0.0446	0.8394	-1.7390	-0.7096
7	2.40	3.08	2.9	3.82	1.2043	1.2378	0.3754	-0.2352	0.7633	0.5111
8	2.25	3.16	3.3	3.61	1.4679	1.1431	1.5821	0.6924	1.4010	-1.201
9	2.37	3.22	3.15	3.57	1.3291	1.1076	1.5821	-0.779	1.4010	-0.667
10	2.32	3.24	2.94	3.57	1.2694	1.3277	0.1530	0.5911	0.9335	0.3243
11	2.46	2.95	3.13	4.04	1.2713	1.3681	0.4791	1.1148	-1.1672	0.5482
12	2.49	3.27	3	3.86	1.2057	1.1782	1.039	0.1953	0.4373	-1.571

4. CONCLUSIONS

Solari's work is based on continuous measurements with modern anemometers and an extensive acquisition [2]. A typical 1-hour sample of a stationary and Gaussian event recorded by the anemometer displays relatively high mean wind velocity (mean velocity averaged on one hour is 12.94 m/s and a 1 second gust peak is 20.40 m/s), the turbulence intensity 0.16 corresponds to a standard II category terrain and the gust factor, *G* of 1.58 is typical of neutral atmospheric conditions; the value of the skewness over one hour record is -0.08 and the kurtosis is 3.25 confirming the Gaussian distribution.

Records of thunderstorms displays lower mean velocities high peak values and gust factors of more than 2…3 and a non-Gaussian distribution; in the case of gust fronts the same low mean values, high gust factors but skewness and kurtosis denote a moderate non Gaussian distribution.

Finally, a very important aspect is that the turbulence intensity varies with the intensity of the event, increasing in the case of the thunderstorms and the gust fronts.

The raw data from Iasi airport are not the result of continuously records; the result consist in successive separate events with mean and maxima values of very

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different level of intensity of the whole measured values during a specific event, the identification of certain specific characteristics is possible.

NP 082 presents the following data for Iasi, by artificially extension of the observation period: maximum speed of 40 m/s, which is also the characteristic value for 0.98 probability of non-exceeding, mean of maximum speeds/year, 22 m/s and skewness 0.3.

From the data gathered at site and averaged on 3 sec periods, presented in Table 1, it is not possible to put in evidence these standard data; still the similarity with the data presented by Solari is evident, mainly the G values, the skewness and kurtosis. In Figure 1 a, b typical Gumbel maxima distributions may be observed. The statistical descriptors in Table 2 show the random process of the wind speed; the low mean values and high maxima values, the gust factors of more than 2, up to 4.5 are not uncommon, these values being associated with wind pressure local or global coefficients in the codes of design to wind action [6]. But these values show that whether continuous observations were developed, similar values to the ones reported by Solari and associated with wind manifestations other than those developed in neutral stable atmosphere. In this case steps for identification the thunderstorms and the gust fronts must be done by site observations at natural scale.

A mixt climate at small scale in laboratory may be identified if the statistic descriptors that characterize it are known with a relying degree of accuracy. The simulation described in par.3 displays a general aspect of a Gaussian event, being described as stationary and stochastic. The values of the gust factor G of about 1.5 close to the reported values of the maxima wind velocity distributions and the shapes of the distributions presented in Figure 5 a, b show the asymmetry of Gumbel distributions. But the asymmetry varies at least with respect to the position on the height of the tunnel, being both on left and on right side; sometimes the process is symmetric.

In the study however, the analysis of the wind velocities recorded in fix positions in the wind tunnel (at 1 cm and 6 cm height, respectively) was developed by separating the period of observation in time intervals in order to observe the succession of the events. From Table 3 it may be seen from the II and III order moments of the statistical distribution, the skewness and the kurtosis, that the processes have alternative asymmetries left and right. During the time intervals quite symmetric distributions are put in evidence, the statistic indicators of skewness and kurtosis showing a Gaussian process which characterize neutral stable events; but they alternate in time with asymmetrical processes. Although the nature of these events in the wind tunnel is not the same as the one that governs the synoptic dynamics, it is important to understand there meaning and their possible role of alteration of the simulation.

On the other hand, if more extensive data acquisition is available describing non neutral stable atmosphere events, the simulations can take into account this fact by modelling the process in the wind tunnel by adjusting the time intervals when measuring the speed and the turbulence scales.

More accurate statistical processing of the simulated events is a step further in modelling the natural events that affect in a most unfavourable way the built habitat.

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